



# **PLANNING FOR THE INTRODUCTION OF NEW TECHNOLOGIES ON SHIP SYSTEMS: A SYSTEM DYNAMICS COST ANALYSIS APPROACH *PROGRAM OVERVIEW***

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*System Performance Laboratory/Virginia Tech*

*Northrop Grumman Newport News*

*NAVSEA 017*



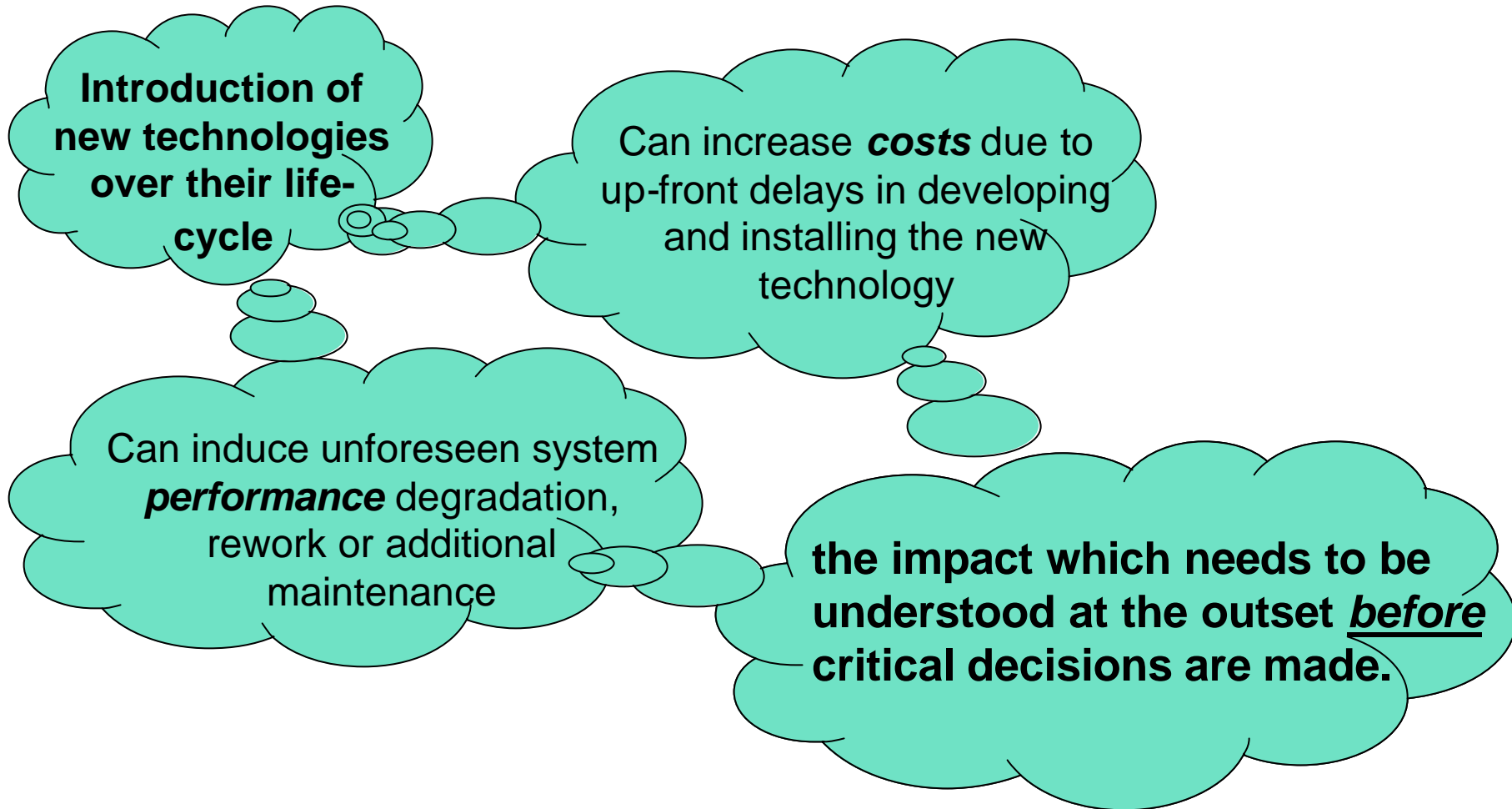


# Presentation

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- Problem
- Goals
- Benefits
- Approach
- Accomplishments
- Lessons Learned

# The Problem





# Potential for Cost Avoidance

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- The approach allows for:
  - Estimating cost overruns
  - Identifying means to avoid overruns and reduce other costs
- For example, estimated potential cost overruns for PEBB AESS technology
  - \$200K Technology Development
  - \$2.0M Technology Integration
  - \$1.8M Operations Support & Disposal
- For 140 total technologies
  - Average estimated 4.0 M cost overrun.
  - Potential cost avoidance of at least \$560M



# Problem Resolution

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Apply a flexible, simulation-based approach that enables scientists, managers, engineers, and analysts to:

- Determine the best process for introducing the new technology
- Consider the life-cycle cost of the new technology
- Evaluate and improve
  - The performance of the new technology
  - The skills of the developers and users of the new technology
  - The system structure and performance
- Initiate high level planning and cooperation between:
  - Procuring organization (Government)
  - Suppliers (Shipyards, Vendors, etc.)
  - Customers (Fleet)



# Project Goals

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- Design a simulation-based affordability approach for the *discovery* of the impact of introducing new technology into ship systems
- Develop a better decision-making approach for introducing new ship technologies that:
  - Makes a contribution to affordability science
  - Captures important interactions among key processes and phases throughout the technology's life cycle
  - Facilitates learning among decision-makers
  - Determines a cost estimate range
  - Fosters transition to government and industry
- Generate models that require minimal level of effort to implement



# Modeling Approach

- Complexity of new systems no longer allows problems to be solved with “off-the-cuff” solutions and mental models
- We need to represent complexity in order to:
  - Understand how the system structure creates observed behavior
  - Represent the long and short term effects of our actions
  - Capture the side effects of our decisions
  - Evaluate the consequences of alternative policies
- Our ability to influence the behavior of a total system depends on our ability to:
  - Understand relevant subsystems that make up the system
  - Focus on re-designing the system

*“Mental models are deeply ingrained assumptions, generalizations or even pictures or images how we understand the world and how we take action. Very often we are not consciously aware of our mental models or the effects they have on our behavior.”*

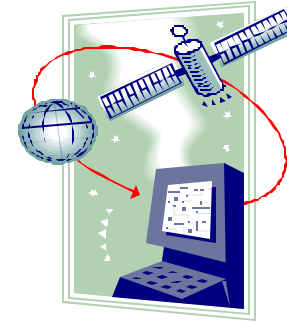
-Peter Senge, The Fifth Discipline (1990, p.8)



# Real World versus Modeling (Virtual World)



- Unknown structures
- Complex
- Long Time Delays
- Inability to Conduct Controlled Experiments



- Known Structures
- Variable Level of Complexity
- Ability to account for the impact of time delays
- Controlled Experimentation



# Customer Communities

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- Science and Technology
  - Technology requirements
  - Technology research and development
  - Technology integration and transition
- Acquisition
  - Engineering design/development
  - Production planning and equipment
  - Fleet introduction
- Operations and Support
  - Operational deployment and employment
  - Logistics support and training
  - Process and product improvement



# Relevant Customer Questions

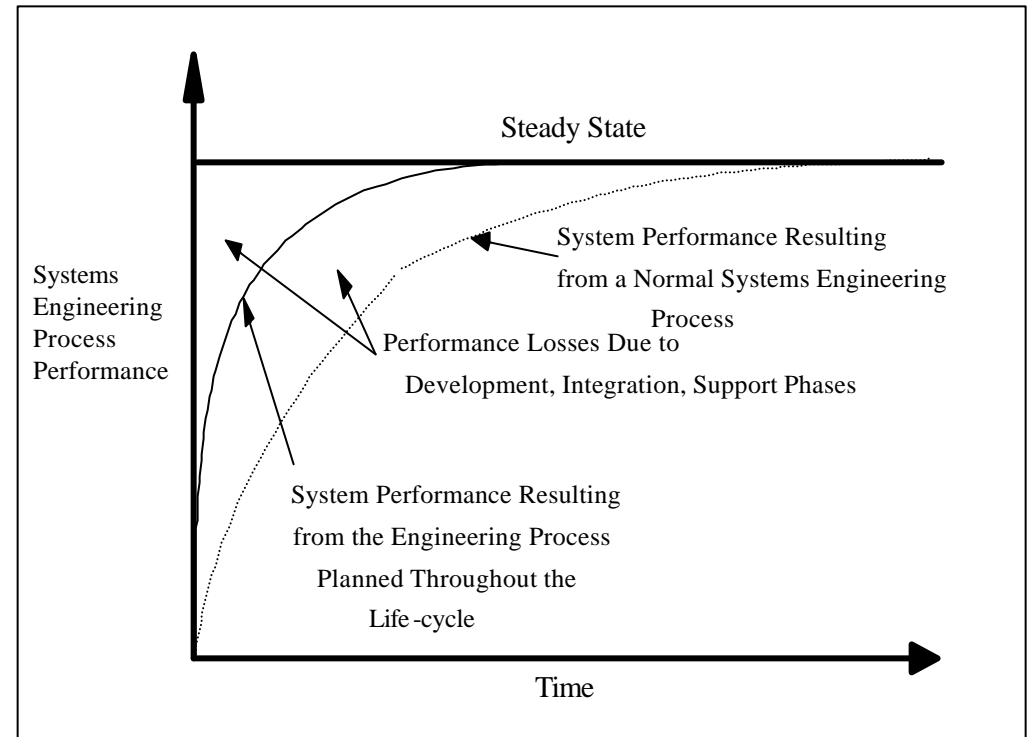
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- How are the technology development, integration, and support activities integrated?
- How do the development, integration, and support activities contribute to life-cycle system cost performance and will congressional budgets sustain these activities?
- What is the impact of technology maturity and complexity on risk?
- How does risk impact development, integration, and support activities?
- What is the impact of rework and training on new technology introduction?
- What are the improvements (re-engineering efforts/policies) that will improve the systems engineering process that is responsible for the introduction of new technologies?



# Cost Management Opportunities

- Traditional methods do not always integrate:
  - *Technology Development*
  - *Ship Integration*
  - *Operations & Support*
  - *Disposal*
- Cost is not always evaluated as an integral element of technology insertion decision-making
- Cost is not evaluated dynamically over time





# Modeling Applications

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- Technology introduction assessment/evaluation
  - Impact of risk, maturity, complexity, rework
  - Impact of technology system performance (e.g., cost overruns)
- Improved decision-making
  - Understanding key interactions over the technology's life-cycle
  - Facilitate communication among decision-makers prior to commitment to new technologies
- Identification of policies
  - Training
  - Budgeting

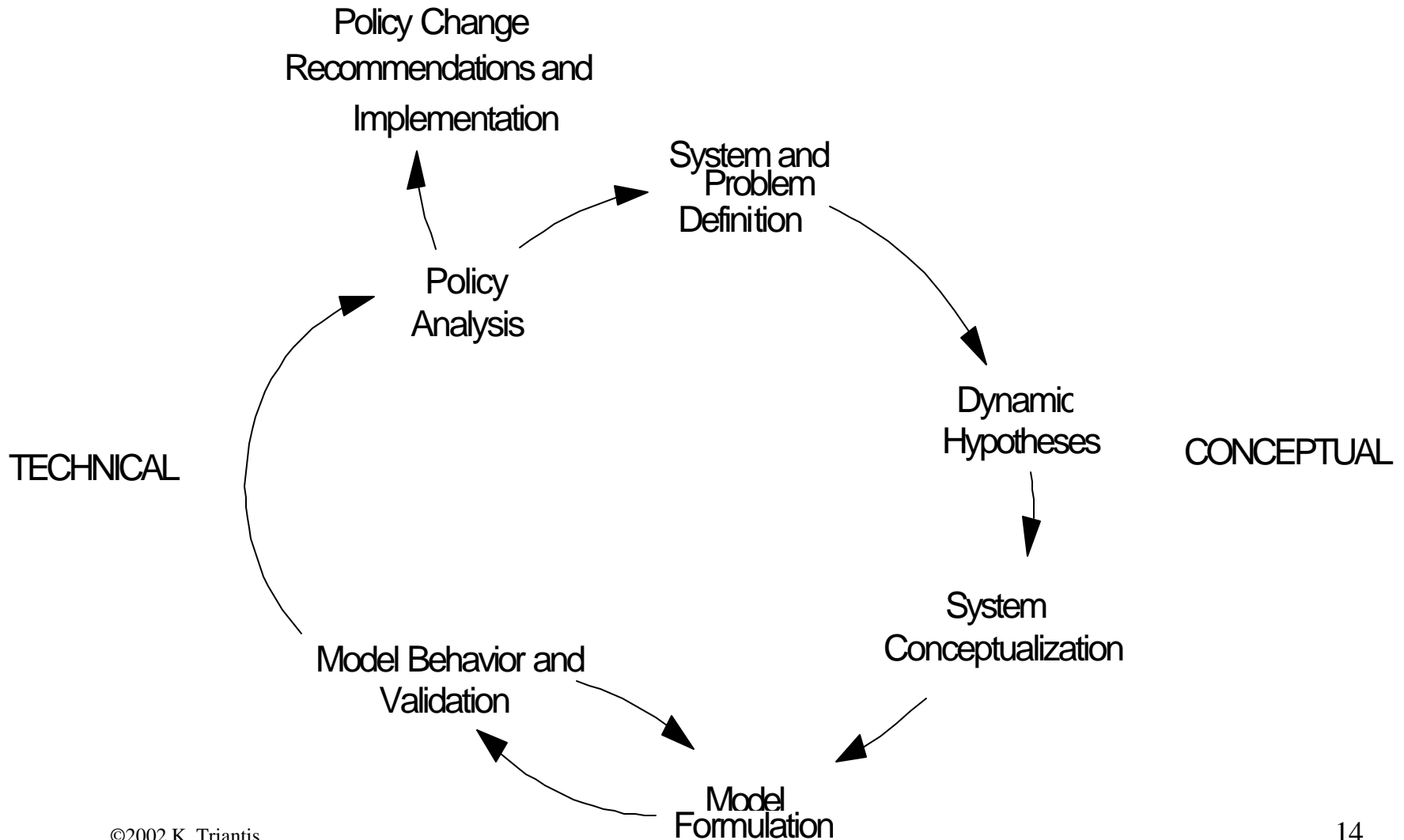


# Benefits

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- Trade-off methodologies that:
  - are applied early in the acquisition process
  - can be tailored to the technologies under study
  - are robust in terms of applicability and sensitivity
  - accommodate customer input and participation in decision-making
  - allow “what if” analysis of alternative policies
- Navy systems that are:
  - re-configurable
  - survivable
  - *affordable*
  - supportable
  - maintain required performance levels.

# Project Logic





# Program Plan

## Virginia Tech

Problem Definition

Establish Performance Measurement Team

Develop Causal Loop / Stock and Flow Diagrams

System Dynamics Model Development

## Northrop Grumman Newport News

Identify Technology

Define Problem

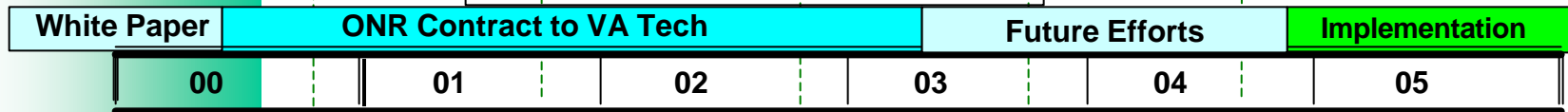
Support Diagram and Model Development

## NAVSEA 017

Identify Technology

Define Problem

Support Diagram and Model Development



10/01/01

10/1/02

10/01/03

10/05

VA Tech  
Funded

Newport News / 017  
Contract Award

FY02 Funding

Pursue continued  
funding for 03/04

NAVSEA 017 / Northrop  
Grumman Newport News  
Implementation



# Plan of Action and Milestones

ACTIVITY	2 <sup>ND</sup> QTR 2002	3 <sup>rd</sup> QTR 2002	4 <sup>th</sup> QTR 2002	1 <sup>st</sup> QTR 2003	2 <sup>ND</sup> QTR 2003	3 <sup>rd</sup> QTR 2003	4 <sup>th</sup> QTR 2003	1 <sup>st</sup> QTR 2004	End of 2004
Complete initial prototype model for all subsystems	▲								
Complete initial subsystem validation using PEBB technology		▲							
Integrated (all subsystems) model testing		▲							
Initial model demonstration			▲						
Model updates / additional technology validations				▲					
Update model subsystems					▲				
Deploy Prototype to select activities for review and feedback					▲				
Experimental Critique & Develop Deployment Plan							▲		
Final Product Development								▲	
Transition to User Community (Final Deployment)									▲



# Research Partnerships

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- Participants in the group modeling elicitation sessions include:
  - SPL (Triantis, Monga, Siangdung, Scott, Damle)
  - Northrop Grumman Newport News (Schatzel, Kerr)
  - NAVSEA 017-Cost Estimating Group (Chewning, Ray, Moy)
  - ONR/ANTEON (Drew/Keller)



# Accomplishments

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- Established measurement team
- Conducted thirty group modeling sessions since January 2001
- Selected PEBB (Power Electronic Building Blocks) AECS (Aircraft Electrical Service Station) technology to demonstrate the approach and develop the prototype model
- Completed:
  - Tech Development prototype model and documentation
  - System Dynamics Structure that incorporates key productivity notions
  - Updated problem definition, hypotheses formulation, model conceptualization for all subsystems



# Efforts Under Way

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- Continuing or finalizing:
  - Prototype models for:
    - Technology Integration
    - Operations, Support and Disposal
  - Documentation of research results in terms of theses and research papers
- Initiated:
  - Validation/verification
  - Policy analysis



# Future Work

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- Formulation of deployment plan
- Experimental Critique
  - Experiment with multiple technologies
  - Feedback from multiple users
  - Feedback from system dynamics experts
  - Feedback from the academic community
  - Lessons learned from other models that address the same problem but geared for different systems/organizations
- Transition from prototype/pilot version to beta version
  - Establish GUIs
  - Finalize documentation
  - Define initial user community within industry and government
- Transfer product to customer community



# Lessons Learned

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- The model is fundamentally useful in the hands of decision-makers (scientists, engineers, managers)
  - Decisions are a function of evaluating different “tradeoffs” or “what if” scenarios
- For each subsystem we have gained fundamental insights
  - Insights potentially lead to sound decisions about
    - Changes to the systems engineering process
    - Introduction of new technologies



# Lessons Learned

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- Mental models have significant impact on the modeling process
  - Users who have not been part of the process tend to project their own mental models
  - Some mental models are not necessarily consistent with the “converged” mental models of the decision-makers who have been part of the process
  - Naïve users only concerned with specifying the parameters associated with the technology and completing sensitivity analyses
- Once additional users become part of the process
  - The model itself will change dynamically
  - New mental models are introduced
  - Information about the systems engineering process will be incorporated



# Lessons Learned

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- Data collection
  - Is a necessity for specifying model parameters
  - Leads to the identification of key issues
  - Enables the user to successfully complete and understand the “tradeoffs”
- Requirements and Budget Relationship
  - Lack of alignment of the engineering requirements and the budget process can significantly contribute to poor cost performance



# Group Modeling Lessons Learned

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- The process is inherently “messy” and time consuming regardless of structure
- Distributed teleconferencing technology is effective once face-to-face group modeling sessions have been conducted
- Success of group modeling process depends on
  - Discussions concerning fundamental issues
  - Off-line preparations
  - Data collection from real systems



# Project Innovations

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- Structured interface between
  - System dynamics
  - Introduction of new technologies
- The application of distance learning technology to facilitate the systems dynamics group modeling process.



# Summary

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- Problem
- Approach
- Work Continues
- Feedback
- Transition



# Contact Data

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